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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Chemistry 2023

91164 Demonstrate understanding of bonding, structure, properties and energy changes

Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of bonding, structure, properties and energy changes.	Demonstrate in-depth understanding of bonding, structure, properties and energy changes.	Demonstrate comprehensive understanding of bonding, structure, properties and energy changes.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

A periodic table and other reference material are provided in the Resource Booklet L2–CHEMR.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–12 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area (DO NOT WRITE IN THIS AREA DO NOT WRITE). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

QUESTION ONE

(a) Ethanol, CH_3CH_2OH, can be used as a biofuel. Biofuels are formed from materials made by living organisms. The production of ethanol and carbon dioxide, $CO_2(g)$, from glucose, $C_6H_{12}O_6$, is shown in the equation below.

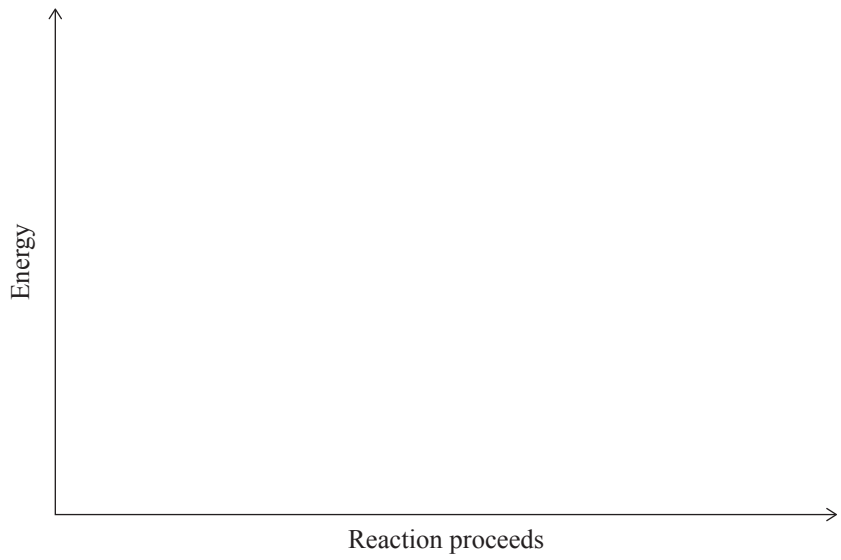
$$C_6H_{12}O_6(aq) \xrightarrow{\text{yeast}} 2CH_3CH_2OH(aq) + 2CO_2(g) \qquad \Delta_r H = -72 \text{ kJ mol}^{-1}$$

(i) Is this process endothermic or exothermic?

Provide a reason with your answer.

(ii) Draw a labelled energy diagram for this reaction, showing reactants, products, and the change in enthalpy, $\Delta_r H$.

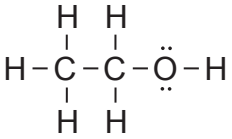
Note that yeast is a catalyst in this process and should not be included in the diagram.



(iii) Calculate the energy change when 161 g of ethanol is formed.

$M(CH_3CH_2OH) = 46.0 \text{ g mol}^{-1}$

(b) The Lewis diagram for ethanol is shown below.



Atom	Bond angles around atom
Carbon	109.5°
Oxygen	109.5°

Compare and contrast the shape and bond angles around the carbon and oxygen atoms in ethanol, with reference to VSEPR theory.

(c) Ethanol is the major component in alcohol-based hand sanitisers. A student noticed that after rubbing the hand sanitiser on their hands, it readily evaporated, leaving their hands feeling cool. The equation for the evaporation of ethanol is shown below.

$$CH_3CH_2OH(\ell) \rightarrow CH_3CH_2OH(g)$$

(i) Circle the word that describes the change in enthalpy $\Delta_r H$, for the evaporation of ethanol.

Positive $\Delta_r H$ **Negative $\Delta_r H$**

(ii) Explain why ethanol readily evaporates, and why the evaporation of ethanol results in the student's hands feeling cool.

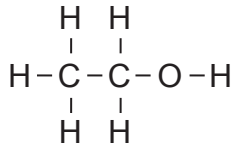
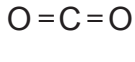
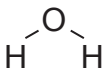
In your answer you should:

- consider the transfer of energy occurring during the evaporation process
- refer to the structure and bonding present in ethanol.

QUESTION TWO

Ethanol is used as a fuel by reacting it with oxygen gas, $O_2(g)$, in a process called combustion. The combustion of gaseous ethanol, $CH_3CH_2OH(g)$ is shown below.

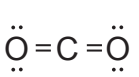
$$CH_3CH_2OH(g) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g) \qquad \Delta_r H = -1370 \text{ kJ mol}^{-1}$$

 CH_3CH_2OH	 O_2	 CO_2	 H_2O

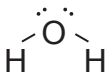
(a) Use the change in enthalpy ($\Delta_r H$) for the reaction above and the bond energies listed in the table below to calculate the average bond energy of the O=O bond.

Bond	Bond energy (kJ mol^{-1})
C–C	348
C–H	413
C–O	358
C=O	805
O–H	463

(b) The products of the combustion of ethanol are carbon dioxide, CO_2, and water, H_2O.



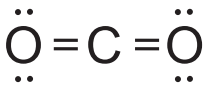
CO_2



H_2O

(i) Carbon dioxide contains carbon and oxygen atoms. Oxygen is more electronegative than carbon.

Draw two arrows (↔) OR add δ^+ and δ^- symbols onto the carbon dioxide molecule shown below to represent the bond dipoles present in the carbon dioxide molecule.



(ii) Circle the word that describes the polarity of each molecule below:

Carbon dioxide (CO_2)	**Polar**	**Non-polar**
Water (H_2O)	**Polar**	**Non-polar**

(iii) Compare and contrast the factors that influence the polarity of these two molecules.

(c) The combustion of fuels can result in toxic by-products, such as carbon monoxide, CO.
A catalytic converter can be used to convert these compounds to less harmful substances.
Catalytic converters often contain the element palladium, Pd.

(i) Complete the table below for each of these substances in their solid states.

Substance	**Type of solid**	**Type of particle**	**Attractive forces**
Carbon monoxide, CO(*s*)			
Palladium, Pd(*s*)			

(ii) When exposed to exhaust gases greater than 300 °C, palladium remains in its solid state.

Use your knowledge of structure and bonding to explain the high melting point of palladium.

QUESTION THREE

(a) Draw the Lewis diagram (electron dot diagram) for each of the following molecules, and give their shapes.

Molecule	PH_3	BCl_3	$COBr_2$
Lewis diagram			
Name of shape			

(b) The formation of carbonic dibromide, $COBr_2(\ell)$ is shown in the equation below.

$$2C(s) + O_2(g) + 2Br_2(\ell) \rightarrow 2COBr_2(\ell) \qquad \Delta_r H = -145 \text{ kJ mol}^{-1}$$

(i) Calculate the mass of carbonic dibromide formed when 1150 kJ of energy is released.

$M(COBr_2) = 187.8 \text{ g mol}^{-1}$

(ii) A chemist wishes to store this mass of carbonic dibromide in a 1 L flask.

If 1 mL of carbonic dibromide liquid has a mass of 2.52 g, will they be able to contain it within the flask?

(c) Carbonic dibromide, $COBr_2$, does not conduct electricity in either the solid or liquid state. However, another bromine-containing compound, lithium bromide, LiBr, conducts electricity when molten, but not when solid.

Elaborate on the electrical conductivity of both carbonic dibromide and lithium bromide, with reference to the structure and bonding in each compound.

Question Three continues on the next page.

(d) By referring to the attractive forces between particles, explain why lithium bromide, LiBr(s), is unable to dissolve in non-polar solvents such as cyclohexane, $C_6H_{12}(\ell)$, but can dissolve in polar solvents such as water, $H_2O(\ell)$.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER	

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